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## HOMING POWERS OF THE CAT

By Professor FRANCIS H. HERRICK

CLEVELAND, OHIO

NO animal has been so highly extolled on the one hand as a paragon of virtue, and on the other so roundly condemned as an unmitigated nuisance as the domestic cat, which has been associated with man for upwards of three thousand years. Southey once declared that no home was complete unless it had "in it a child rising six years and a kitten rising six months." Friends of the cat never tire of lauding its domesticity, its neatness, its useful services as a destroyer of rodents, the natural grace and beauty of its movements, its affection and even its surpassing intelligence; while its detractors denounce it as an independent, unsocial ingrate, attached to the hearth for the comfort it affords, but seldom wasting any affection on the person who lays the fire or supplies it with food, as incapable of any unselfish devotion and service, a carrier of vermin and disease, and the most cruel and remorseless enemy of bird-life everywhere.

Viewed impartially the cat is a carnivorous animal of rather moderate intelligence; courageous and resourceful when put to the test, it only follows at all times the bent of its strongest instincts; like every feline it has keen tactual, visual and auditory senses, but its nose is small and rather weak; its endurance in relation to its bodily strength is phenomenal, and we can not but admire its marvellous powers of muscular coordination and control; fecund, and endowed with a vitality which in the popular mind extends far beyond life's usual limits, the cat is unsurpassed as mother and nurse, and in this field her instinct is never-failing.

In his excellent economic study of the cat, Forbush<sup>1</sup> reminds us that while partly tamed this animal has not been fully domesticated: "It has not been subdued, confined or controlled, except in rare cases, but is to all intents and purposes a wild animal. In most cases it stays in the home of man, mainly because of the warmth of his fire, the food that it eats and its affection for the location where it was reared. If, by accident or design, anything

<sup>1</sup> Forbush, Edward Howe: "The Domestic Cat," *Economic Biology Bulletin*, No. 2. Boston, 1916.

occurs to interrupt its association with man, it readily returns to the wild;" and Shaler,<sup>2</sup> who is also quoted by this writer, says: "As a consequence of the affection which cats have for particular places, they often return to the wilderness when by chance the homes in which they have been reared are abandoned. Thus in New England, in those sections of the district where many farmsteads have of late years been deserted, the cats have remained about their ancient haunts and have become entirely wild. In this state they are bred in such numbers that their presence is now a serious menace to the birds and other weaker creatures of the country. The behavior of these feralized animals differs somewhat from that of creatures which have never been tamed. They have not the same immediate fear of a man, but the least effort to approach them leads to their hasty flight."

Every one will admit that the cat varies no less in its individual ways and disposition than does its inveterate enemy, the dog, yet its attachment is mainly directed to its home and neighborhood, and while vagabondage may be rarely adopted by choice it is more commonly enforced. "Thousands of families, says Forbush, "go into the country or to the seaside in summer, taking cats and kittens with them, and leave their pets on their return to the city, not knowing, perhaps, that such cruelty is forbidden by law."

Varied and voluminous as the literature of the cat is found to be, especially in the fields of anecdote, general natural history and anatomy, its homing ability has never been previously tested under experimental conditions, though accounts of this notorious power abound in many languages; from time immemorial it has been said that the cat, like the bad penny, always comes back. Probably all cats possess this homing power in varying degrees, and all with fixed abodes might possibly be induced to exercise it under certain conditions; yet in every case the possession of a power, and the tendency to use it should be clearly distinguished; though possession, in this case, be under the firm grasp of heredity, the *use* is determined by experience and the physiological state of the animal at the moment. Thus it is obvious that an animal with dependent young would have a double inducement to return to its home provided local attachments had already taken root; on the other hand, it is equally clear that, whenever an animal is forcibly removed from its abode, the diversions or accidents which are likely to attend it may be of such character as to block or defeat any impulse to return. In every such case the only facts likely to be either known or knowable are that the animal on that occasion did or did not return; we are usually left in complete ignorance of the animal's

<sup>2</sup> Shaler, Nathaniel Southgate: *Domesticated Animals*, New York, 1895.

inherent abilities, of its struggling impulses or even of its efforts, should any be made.

The account of experiments to follow is offered mainly as a sample of this animal's power under certain conditions; they do not admit of the usual methods of control; they can be multiplied indefinitely, but they can not be exactly repeated, since the variables in each case, of which fear is but one, can not be predicted and are bound to influence response.

The mother of the first cat with which we experimented was brought to us in a basket from a town ten miles distant, and never left us until the following year, when she began to raid the birds on our premises and was given away; her offspring, to which I shall now refer, was born and reared on our place and, so far as we knew, it had never left it; at the time of which I speak it certainly had not shown any roaming propensities. The first six weeks of this kitten's life was spent in the barn, where it received little or no attention, and became so wild that it scarce could be handled with impunity. Shortly after this the mother began to bring it into the house; she always entered by a glass-door, which opens to a piazza at the rear, and soon formed the habit of scratching at the glass whenever she wished to be let in or out. The kitten soon acquired the same habit and lost its wild ways completely; in time it became a handsome home-loving house-cat, and we were sorry to part with it, but at the age of fifteen months, when we had to choose between its companionship and that of any nesting birds upon our grounds, its banishment became inevitable.

The first experiment casually made with this cat led me to suspect that it was impossible to turn some Thomases around, and I determined to investigate this point further at the first good opportunity. This cat was taken in a gunny-sack over an irregular course, mainly by electric car, down a series of hills to a point on the University Campus in the city of Cleveland, 4.6 measured miles from its home in Cleveland Heights; there it was given a dish of milk and the liberty of two rooms, in one of which a window had been slightly lowered at the top. This was on the morning of a Monday, and at five o'clock in the afternoon it seemed to be quite at home in its new quarters; on Wednesday morning, about forty hours later, it suddenly appeared on the back porch of our house and gave its usual signal to be admitted. In order to reach its home this cat had traversed an unknown country, consisting of city or suburban streets and allotments, had crossed the gulley of the Belt Line railroad, probably by one of its bridges, and ascended in the path of greatest resistance a series of terraces to a height of four hundred feet. That its home neighborhood could have been

reached by exploratory movements, on the trial and error order, or by chance alone seemed highly improbable; the only known facts were that it made a homing attempt and succeeded.

When we tried to have this cat repeat its performance in the daytime it would not voluntarily leave the building, and even when set on the ledge of an open window it would quickly drop back to the floor; it was finally left in some shrubbery outside, and when I was called away for a brief time it disappeared and was not seen again. Regretting the loss of this cat through our failure to keep it under continuous observation, we decided to test the homing power, at the next opportunity, in the following way: (1) to take the cat, as before, under such conditions that the possibility of orientation through the receptors of sight, hearing and smell would, in all probability, be completely eliminated; (2) to convey it successively in different directions, and gradually increase the distance at each test, and (3) to release it at a uniform time at dusk, in unknown territory, and under conditions of as free behavior as it was possible to obtain.

The experiments to follow were made with another individual, a female with kittens which were about ready to be weaned; she had been adopted by a neighbor, and her previous history was not known; she was a large and powerful animal (See Fig. 1) and had

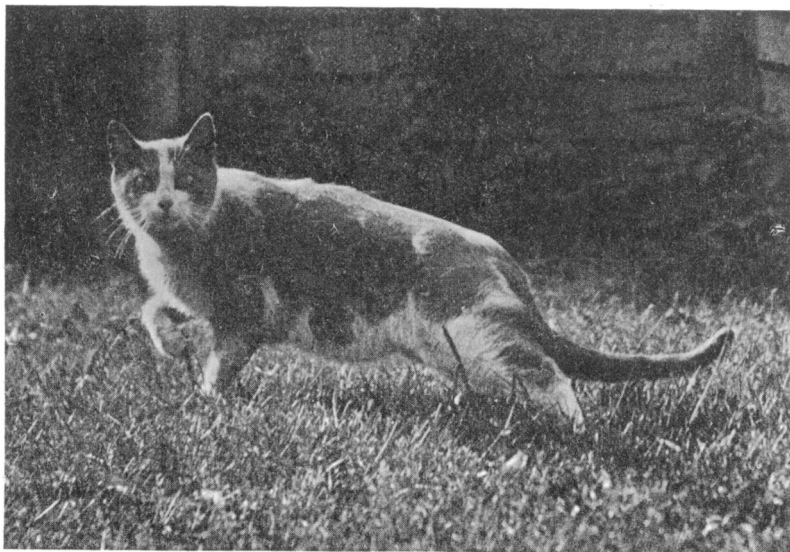


FIG. 1

This cat returned to its home seven times in succession when taken out blindfolded, by automobile, over distances of one to three miles; in the first four tests in the direction of the cardinal points, and in one instance after being put under complete anesthesia.

become such an inveterate hunter of birds and young chickens that her life had been declared forfeit. This cat could not be trusted for a moment when the chicks were about, as my neighbor observed when one evening he tried to entice her from the barn with a dish of fresh milk; thinking, however, that they would be safe as long as we stood by, a brood was released; the cat came to call, but was no longer interested in milk; like a flash she snapped up a chick from under our noses and made off with it to the barn; and this was the third victim of that day. I mention the incident to show how well this animal was able to take care of itself; whatever its history might have been, an experiment to follow proves conclusively, I think, that it had never been a vagrant over those parts of the country to which it was soon to be introduced.

Seven successive returns were made by this cat from points varying from one to three miles from its home, on June 4-23 (See table); she was secured in a sack, carried to the release station by motor-car, and placed under a wooden box which was weighted with

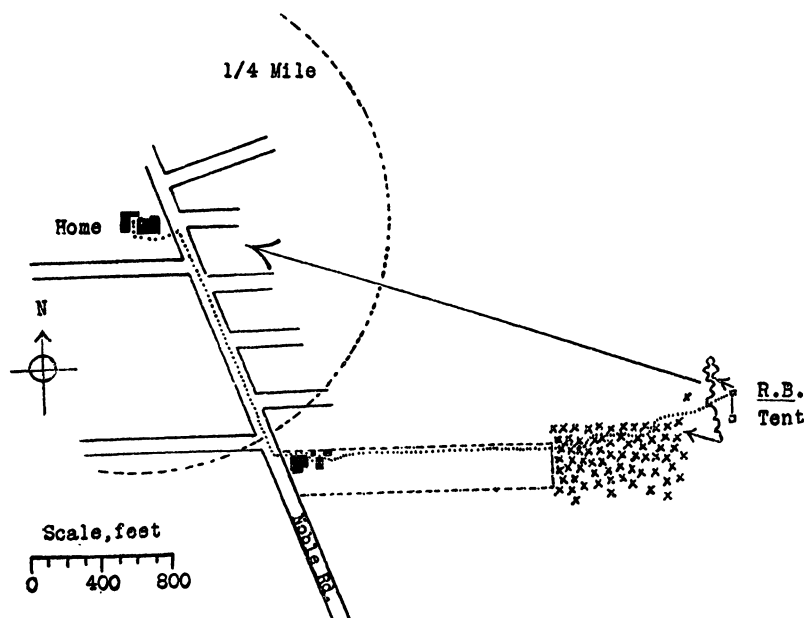


FIG. 2. HOMING OF CAT: EXPERIMENT NO. 2

Home-territory conventionally indicated by circle of one-fourth mile radius. Cat taken blindfolded one mile on course, marked by dotted line, to release-box, R. B. Long arrow marks direct course from release station to center of home-territory; path of cat after release indicated by arrows and irregular line; cat oriented correctly and started in the home-direction, but later reversed her course and made for the cover of woods (crosses) when disturbed by dogs; animal under observation 35 minutes after release. Cleveland Heights, Ohio: June 4, 1920.

stones; the box was raised at the moment of release by a cord operated from a green observation-tent 75-100 feet away; (See Figs. 2 and 3) the cat was given its freedom at about the same time in the evening, and the box was opened towards the north in every experiment except number 4, in which the opening was to the east; we wished to ascertain (1) whether the cat would continue to return to home and kittens when taken at varying distances beyond its known or probable range; (2) whether under such conditions it would orient immediately and correctly; (3) whether after making a correct orientation it would strike off in a *direct line* for its home and pursue that course, or whether it would be mainly concerned with cover and safety first. In tabulating these tests the homing time in all but one instance was less than the estimate given; it could not usually be exactly ascertained; thus if the cat was set free at eight o'clock of an evening, and was found with her kittens again at six on the following morning, the time is given as "10 hours (minus)"; she might have stolen in at any time during the night, and on one occasion was detected at two o'clock in the morning, the probable time of her arrival.

In the first four tests (Nos. 2-5 of the table) the cat was taken

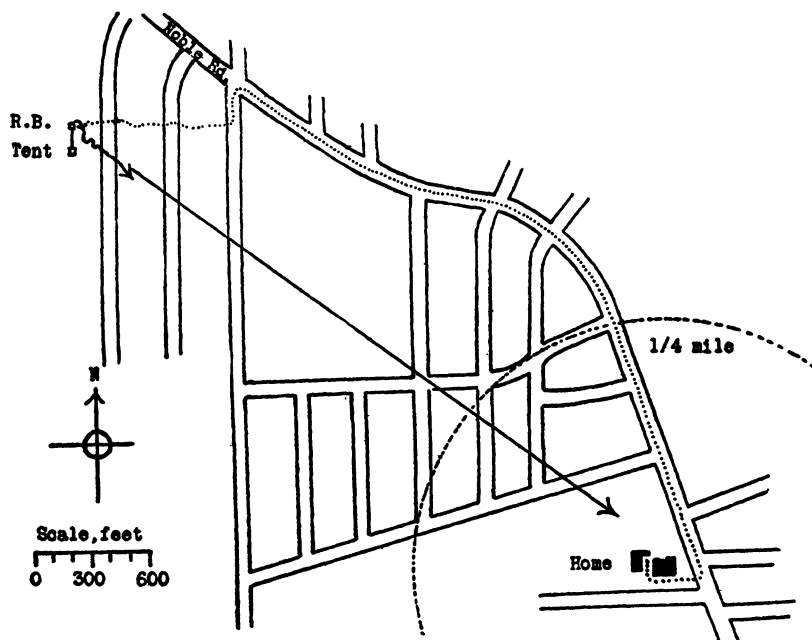


FIG. 3. HOMING OF CAT: EXPERIMENT NO. 5

The cat oriented correctly upon release, and moved undisturbed in a direct line for its home until lost to view; animal under observation six minutes after release. See table for further details; designations as in Fig. 2. Cleveland Heights, Ohio; June 18, 1920.

HOMING POWERS OF THE CAT: RECORD OF EXPERIMENTS

No.	Date	Distance in miles	Station of release	Time of release	Time of return	Homing time in hours
1		4.6 (west)	Campus W. R. Univ. Cleveland	Monday in evening	Wednesday following, 10 A. M.	38 (about)
2	June 4	1 (east)	Open field, 400 ft. from woods	7:25 P. M.	Between 11:30 P. M. Jn. 4 and 7:30 A. M. Jn. 5	8 (minus)
3	June 9	2 (west)	Open field, 150 ft. from highway	8:05 P. M.	Before 6:30 A. M. Jn. 10	10 (minus)
4	June 10	3 (south)	Open field, 900 ft. from highway	7:45 P. M.	2 A. M. Jn. 14	78
5	June 18	1 (north)	Unoccupied allotment	7:55 P. M.	Before 6 A. M. Jn. 19	10 (minus)
6	June 21	1 (east)	Same as in No. 2	7:30 P. M.	Before 6 A. M. Jn. 22	10 (minus)
7	June 22	1 (east)	Same as in Nos. 2 and 6	7:55 P. M.	Before 7:30 A. M. Jn. 23	11 (minus)
8	June 23	1½ (east)	Ploughed field, 200 feet from highway	7:30 P. M.	Before 7:30 A. M. Jn. 26	60 (minus)
9	June 30	16½ (east)	Willoughby, Ohio	6:35 P. M.	No return	

Experiments Nos. 2-9 were made with the same cat; in Nos. 6 and 7 place of release the same as in No. 2; in No. 8 the animal was anesthetized before being taken out; in all cases the cats were blindfolded and taken a measured distance by electric car or automobile.

in the direction of the cardinal points, to distances of 1, 2, 3, and 1 miles respectively, not because we supposed the cat to have any interest in the compass, but simply for convenience in dividing up the available area; we had in mind also the obvious fact that an animal like the cat is liable to establish habits of roaming farther from its home in certain directions than in others, so that any area familiar to it might be described by a very irregular curve, the radii extending half a mile or possibly more in certain directions, or but a few rods in others. In each of these experiments the cat jumped from under the box, as if in response to an electric shock; in every case she oriented correctly to her home region, and started to move in its direction; in one instance (See Fig. 3 and No. 5 of table) she not only started but continued at a rather rapid pace toward home until lost to view, and in this case the right course took her past the tent. It was thus positively shown that there was no necessary backtracking over the course that was followed by the automobile in bringing her out. In the other three cases when the cat had moved but a few yards in the home direction, and then suddenly veered and sought cover in fence-rows or woods,



we found that one or more persons had seen our tent and were moving towards it. The homing time, as pointed out above, could not be accurately determined in the first, second and fourth of these tests, but was probably from four to ten hours; over the course of three miles (No. 4 of table) 78 hours were required.

In the first test (See Fig. 2) the cat sprang from under the box, came to attention, as it were, for a moment, facing in the direction of her home region, which lay a few points north of east; she moved slowly for a short distance on this course, mewing almost continuously, then turned more to the north, and after going a few rods suddenly veered and made for cover in a piece of woods, four hundred feet to the south, passing within a few yards of our tent. At this juncture a farmer's boy appeared on the scene with two dogs, which were soon on the trail, but she out-distanced them and in a moment was safe in a tree; here we left her to her own devices, and all that we knew of her subsequent movements was that by six o'clock on the following morning she was again at home with her kittens. That she returned the same night, and with little delay, is most probable. The grass in the field where this test was made was not at that time very tall, and the cat could be readily seen by one standing erect; whether the bend in the curve marks the point at which the cat first sensed the approach of the boy and the dogs may be doubtful, but there is no doubt that this change in her course was due to a sudden impulse to find cover.

In the second experiment of the series the animal was taken on June 9 over a distance of two miles to a point due west, and  $1\frac{2}{5}$  miles in air-line from its home; the tent was placed in a corn-field, one hundred and fifty feet from the highway, along which automobiles and pedestrians were liable to pass, though rather infrequently: the box was opened towards the north, as before, and the cat, when free, could move in any direction but south without passing the tent, her home-course being a point or so north of east; at the moment of release she oriented perfectly and began moving in the right direction, but as in the previous test she soon swerved to the north; at that moment also two men, who were coming down the street, stopped and made a movement as if to approach the tent; after traveling northward for about a rod, in consequence, as I believe, of this disturbance, the cat stopped, cocked her ears, glanced back at the tent, struck the home-course again and began moving rapidly up the steep hillside; she continued in the direct line for home until lost to view at 8:25 P. M., when it was quite dark; the cat had been under observation twenty minutes, and I believe made her home rather promptly, but she was not seen again until the morning following.

On the very next day this cat was subjected to a more difficult test; she was taken in the usual way over a course three miles to the south, and the tent was pitched nine hundred feet from the road in the hope of avoiding all interference; the release-box was set ninety feet away at the bottom of a run, on ploughed land, and opened eastward, north being the true course home; on this side, seventy-five feet away was a fence, with woods stretching beyond, and at about the same distance south was an unfenced stand of thick grass, while some three hundred feet to the east lay a stone wall bordered with small trees; as before the cat came out with a bound, oriented aright, and moved a few yards on the homeward line; then, as in the two previous tests she wheeled about and travelled in an opposite direction, this time entering the tall grass; in this instance the disturber of the peace was the owner of the land, who had doubtless seen us placing the tent; his approach coincided with the cat's move for cover, and as we stood watching her she gradually worked over to the easterly fence-row. This was at 8 p. m., June 10; at two o'clock in the morning of June 14, or 78 hours later, the mewing of this cat was heard under a window which opened on the lawn of its owner; this, as we had reason to believe, actually marked the hour of the cat's return.

In the fourth and in some respects the most interesting test (See Fig. 3 and No. 5 of table) we carried the cat by motor-car one mile north by east, turned into another road, and placed the tent on newly allotted land two hundred and fifty paces from the highway, and for once succeeded in avoiding all interruptions. The box was opened to the north at exactly 7:55 p. m., the home direction being a few points east of south. As in former tests the cat came out with a spring; she oriented correctly without the slightest hesitation, and at once began moving in a direct line for home; she advanced slowly, paused a number of times, and stood with ears cocked, as shown in the photograph, but never once turned from the chosen course during the six minutes that we were able to keep her under observation; she finally disappeared in a dry water-course which came from the hillside above; there can be little doubt that she made home in good time although she was not detected until early the next day.

The two experiments which followed (Nos. 6 and 7 of table) were merely repetitions of the first, and were undertaken as a check upon this test—to ascertain whether the behavior would be similar in each case, and if the homing time would be improved. In the first of these the cat got free prematurely, took the wrong initial direction, and was soon lost to view in the grass, which by that time had grown quite tall. In the next trial (No. 7), at the mo-

ment of release, she started on the wrong course, but in a moment oriented correctly, and was on the homeward path when she disappeared from sight. In neither case could we determine the time of the cat's arrival, but in all probability she made home the same night.

We have already referred to the fact that many cats revert to the wild or semi-feral state, vagabondage being sometimes adopted by choice, or more commonly it is forced upon them by the neglect of their owners. Had the second cat been a nomad of this character, and in the region about its present home, the experiments just described would have no value as tests of its homing abilities; the whole region for miles around might have been familiar ground. That the territory embraced in these tests was actually new to this animal is, I believe, clearly indicated by the next experiment; the cat was now put under complete anesthesia by chloroform, and conveyed by motor-car, as before,  $11\frac{1}{2}$  miles east by north of its home-site; somewhere towards the end of the journey she recovered from the anesthetic so as to appear quite able to take care of herself when let out of the bag; the animal was accordingly set free, without using the blind, in a field fifty feet from the highway; she made at once for this road, in a direction opposite that of her home, and would have gone beyond it but for a gorge which blocked her path; then she moved beside the road, very nearly back-tracking for several rods over the course which the automobile had taken, and disappeared in the cover of bushes. She returned home, as in all the previous experiments, but only after an interval of 60-70 hours; that is, to home under these conditions from a distance of  $11\frac{1}{2}$  miles, which ordinarily was accomplished the same night, or at most in from eight to ten hours, now required eight times as long. This could hardly have been the case if the cat had awakened to find itself in familiar territory. To hazard a conjecture I am inclined to believe that in this case the cat, finding itself on strange ground, with all relations with its home-region broken, wandered about until its lost orientation was by chance restored through the discovery of familiar objects.

At this stage in our experiments the cat had accounted for so many chickens that its owner was anxious to be finally rid of it; but it had proved so good a "homer" I felt that it had fairly earned its freedom; accordingly it was decided to take a long chance, and it was liberated in Willoughby, Ohio,  $16\frac{1}{2}$  miles from its home, at a point three miles north of the second bridge which crosses the Chagrin River in that section; we hope that it found a good home, where its bird-killing propensities could be more effectively checked; it never returned. It does not necessarily follow that the distance

and other obstacles in this test were too great for this cat's remarkable homing ability, for the longer the course the greater the number of diversions or accidents liable to be encountered; moreover this cat's kittens had now been weaned, and the longer the attempt to home is protracted or delayed the weaker becomes the impulse to return, and the greater the chance afforded for new habits to develop and replace the old.

Possibly most of the stories of cats and other animals returning to their homes from long distances, when not composed in newspaper offices, are exaggerated, or based on inexact identification. As an instance of the latter sort, Claparède<sup>3</sup> mentions the story of a cat taken from Montilier on the shore of the lake of Morat to Lausanne, a distance of 50 kilometers (about 31 miles), and said to have returned the following day to its old home, a statement ample in itself to refute the account; an investigation, moreover, by Emile Yung, Professor of Zoology at the University of Geneva, proved that the cat had never left Lausanne, the one seen at Montilier being another individual of the same size and color. Claparède, however, records on reliable testimony the case of a cat carried in a basket 18 kilometers (11 1/5 miles) by rail to Geneva, and afterwards returning to its former home at Céligny. In a characteristic "Souvenir" Fabre<sup>4</sup> has told the story of the cats, which accompanied him and his family whenever he was obliged to change his domicile; in going by carriage from Orange to Sérignan, a distance in straight line of 4 3/8 miles, the oldest cat was confined in a basket, and upon arrival it was made a prisoner for a week in the hope that it would become habituated to its new abode; but all to no purpose, for upon regaining its freedom it returned at once to Orange. When found at its former home the animal was wet to the skin, and its body was smeared with red earth, an evidence, as Fabre thought, that it had crossed the Aygues, a tributary of the Rhone, and afterwards gathered up the dust of the fields; it was May, he said, and there was no mud; two bridges cross this stream one at a point above, and the other below, the course the cat must have followed; but, said Fabre, it took neither, its instinct directing it home by the shortest course, and it even overcame its repugnance to water in order to reach its beloved abode. Upon similar evidence Fabre concluded that another of his cats had returned by crossing the river Sorgue, at Avignon, where it avoided the bridges in order to follow the more direct route.

<sup>3</sup> Claparède, Ed.: "La Faculté d'Orientation Lointaine," *Archives de Psychologie*, ii: pp. 133-180, Geneva, 1903.

<sup>4</sup> Fabre, J.-H.: *Souvenirs Entomologiques*, ii, pp. 124-133, Paris.

Hodge<sup>5</sup> records an interesting experiment with a large tomcat, which he and his friends took with them in a boat one dark summer's night, on a lake at Madison, Wisconsin; after a time, says Hodge, the cat became very restless and anxious to go home; he would climb out to one end of the boat, and stretching his head towards home, mew almost continuously. Hodge and his friends then amused themselves by turning the boat slowly round and round, first one way and then another, to see if they could throw Tom off his bearings; but all to no purpose for, says Hodge, "whether right side, left side, bow or stern, Tom was always on the part of the boat nearest home, and straining as far as he could in that direction. Fully a mile from any shore, how could he tell which shore was which?" But few lights were visible on the shore, and none of the party was able to distinguish their own cottages. They then wrapped Tom in a heavy blanket-shawl, and held him first on the lap and then flat on the bottom of the boat, while it was turned round as before; but whenever released, the cat started "with never a mistake and without the slightest hesitation towards the end of the boat nearest home. Whether the boat was turned by a single stroke, as on a pivot, or rowed slowly around in a circle, the result was always the same. Members of the party were blindfolded and required to guess whether the boat was turned or allowed to stand still, or was rowed in a straight line or in a circle; and it was an even chance whether they guessed right or wrong." The tomcat kept his bearings better than any of them. Hodge was inclined to believe that the cat's direction-constant was its sense of hearing and its ability to detect sounds on shore which were too faint for the human ear.

From the experiments recorded above, though few in number, I think that we are justified in drawing the following conclusions: (1) That the returns in experiments 1-5 and 8 were made from unfamiliar territory; (2) That in the tests 1-5 success did not depend upon chance; (3) That the cat did not return over the course taken by the motor-car on the journey out, or according to a so-called "law of reversal" (*loi du contrepied*), as suggested by Darwin, and revived by Bonnier and Regnaud; (4) That the homing power in a more or less direct line is independent of the sense-receptors of vision, hearing and smell; (5) That under the conditions described the cat is able to home at night, and probably does so by preference; (6) That its power of return is not affected by rotation or any ordinary treatment, barring possibly anesthetization, which the animal may receive, prior to or during the journey to the point of liberation.

<sup>5</sup> Hodge, C. F.: "The Method of Homing Pigeons," *Pop. Science Monthly*, Vol. 44, New York, 1893-94.

The problem of homing or of "distant orientation" in the higher animals is very ancient, and the literature of the subject, particularly as concerns the carrier pigeon, is voluminous and vexed to the last degree. Claparède in 1906 reviewed the whole field, and discussed the various theories to which the question of homing has given rise; again in 1915 Watson and Lashley<sup>6</sup> gave a résumé of the whole question in vertebrates, and a concluding account of their remarkable experiments on the homing powers of the Noddy and Sooty Terns; they showed that many of these birds when taken from their nests on Bird Key, Tortugas, Florida, and carried upwards of 800 miles in various directions at sea, made successful homing flights; their birds were untrained; they returned from territory through which they had apparently never passed, and over the open ocean, which could afford no landmarks, visible at least to the human eye. Their results, though admittedly negative, disproved certain theories of homing; they found no "special tactual or olfactory mechanism situated in the nasal cavity," which might function for distant orientation, but thought it "just possible" that the terns might "possess on certain parts of the body (eye-lids, ear covering or oral cavity) sensitive tactual and thermal mechanisms which might assist them in reacting to slight differences in pressure, temperature and humidity of air-columns."

We are now concerned only with the powers of an animal standing low on the ground, and moving rather slowly, in orienting to a known goal—its home, and in homing successfully and repeatedly by passing through territory unknown to it. The cat's known goal, it should be remembered, is not a point but a region, which if irregular, may be quite extensive; whatever the form of this familiar area might be, a cat would be as much at home upon any part of it as when on the hearth of its master's house. The bird, which orients to a region of far greater size, could be expected to have the power of returning to it from a correspondingly greater distance; and if there is a distinction between proximate and distant orientation there must be a division of territory surrounding the goal or its center based upon the presence or absence of familiar landmarks of some sort.

Wallace<sup>7</sup> maintained that the cat was able to return to its home by the aid of its olfactory sense, that is by picking up in reverse order, link by link, a chain of different odors, which it had expe-

<sup>6</sup> Watson, J. B., and Lashley, K. S.: "Homing and Related Activities of Birds," Carnegie Institution of Washington, Publication No. 211, Washington, 1915.

<sup>7</sup> Wallace, Alfred Russel: "Inherited Feeling," *Nature*, vii, p. 303, London, 1873; also "Perception and Instinct in the Lower Animals," *ibid.*, p. 65.

rienced in its going out; in other words the cat smelled its way out and back, though leaving no tracks of its own. Aside from the assumption that the cat possesses an acute sense of smell, which is probably erroneous, not to speak of the necessarily mixed and transitory character of all odors in the air, we have seen that as a matter of fact the cat does not always return over the course by which it was taken out; on the contrary it often follows the shortest and most direct route. Darwin<sup>8</sup> thought that the power of returning to a region from which an animal had been deported, when indications were lacking, might imply the faculty of keeping a dead reckoning or of registering the various deviations or turns made in course of the journey; he declined, however, to discuss the question as his data were insufficient.

Since the animal does not always or usually return, as we have seen, over the original course, it is evident that it is not called upon either to exercise a prodigious memory or to repeat reflexly or otherwise the movements which such a supposed "backtracking" would imply.

We have shown that the cat can return at night, and think it probable that it homes mainly during the hours of darkness. In the greatest distances covered in these experiments (Nos. 4 and 1) or 3 and 4.6 miles, respectively, the animals had in one case 28½ hours and in the other 17 hours of night-time available; if they moved forward only or mainly after dark the first would have taken an average of nine hours to the mile, while the last would have cut this to four hours, which is rather good time for an animal which travels as slowly and cautiously as the cat.

When we are thus brought squarely before the problem of accounting for the return of this animal to its home region under the conditions described, we find no solid ground on which to tread; what follows must be regarded as mainly conjecture: (1) The animal seems to have a direction-constant with reference to its home-region, which it retains through the journey out, in spite of all the manifold turnings and twistings to which its body may be subjected; the animal will not have to recover what it does not lose; if this direction-constant is lost the animal will be lost; (2) This power of maintaining orientation does not depend upon memory nor, as already indicated, upon the receptors which mediate vision, hearing or smell; (3) We get over no difficulties by assuming, as has been often done, a "sense of direction," for direction to such an animal, it would seem, can mean only the spatial relation between its body and such objects as appeal to it; and out

<sup>8</sup> Darwin, Charles: "Origin of Certain Instincts," *ibid.*, p. 417.

of the total effective environment of the cat no objects probably make a stronger appeal than its home or the young which it may shelter; (4) Though of course possible, it is rather improbable that an animal like the cat possesses important unknown sense-organs which come to its aid in orientation; (5) By the process of exclusion we seem to be thrown back upon (a) mental imagery, or a relation established between the visual and the visualized fields, and (b) the kinesthetic sense, the sense of movement, or as it is sometimes called the "muscle sense," which is of sufficient delicacy to yield an impulse to action whenever the body is moved.

It may be too great a tax upon our credulity to believe that the cat can form and utilize mental images in such an effective way as do human beings, and especially since blindfolding does not appreciably affect the homing power. Accordingly I am inclined at present to believe, though unable to prove, that the secret of this power lies in the kinesthetic sense, which is older by far than either seeing, smelling or hearing, and by which compensatory movements of the body can be made and maintained; in other words that the constant sought lies back of the ordinary sense-organs, and that this is in some way bound up with this primitive muscle sense, which experiment has already shown to be of far greater delicacy in many animals than in man. It would seem that Hodge's cat, to which we referred, perceived every movement of the boat, and compensated for the movement when given its freedom; if the water in that lake had suddenly become dry land, is there any doubt that the animal would have made its home in short order, as our cats have repeatedly done, when removed a much greater distance from hearth and young, and when blindfolded at that?

Whether deviations in the position of the body are constantly adjusted by compensatory movements of some sort is a matter which future experiment must decide; it did not occur to me to keep the cats under close observation during their journeys out. It does not seem probable that such an animal is able to keep a register of its movements, if it were called upon to do so, in the way Darwin suggested; were this the case it would be a perfect homing machine.